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SMT PRECISION LEAD-FREE REFLOW OVEN

USER MANUAL

Associated publications

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Before Baking…, *Elektor* October 2008.
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Any use of the oven not explicitly described in this manual is strongly advised against and will void purchaser's warranty.

Equipment not suitable for heating foodstuffs, liquids or tissue.

Equipment must not be used in the vicinity of children, animals or unqualified people.

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Introduction

The Elektor SMT PRECISION LEADFREE REFLOW OVEN is an electrical appliance used for production and maintenance of circuit boards using SMT (surface mount technology) components. The equipment employs far-infrared heating elements as well as high quality temperature sensing devices and materials. By means of accurate control exercised by an internal microcontroller, temperature curves are obtained that closely match the requirements of circuit board production using SMT. The temperature control curve of the equipment can be adjusted accurately, allowing optimum use of a wide range of solder paste products with different material parameters. The oven can shut down and supply fault alarms automatically. Its functions cover PCB soldering and reworking as well as SMD drying.
The performance and operation of the oven have been upgraded and improved from a previous version.

Main technical features

Line voltage:	230 VAC
Line frequency:	50-60 Hz
Max. power consumption:	1650 W (10 A fused internally)
Heating methods:	infrared radiation and hot air mixed heating
Menu languages:	English or German (partly)
Readout:	LCD, Text mode or Graphics mode
Modes of operation:	automatic reflow soldering; repair (maintenance); temp. adjustable
Temperature phases (curve sections):	Preheat, heat, solder, heat retention, cool down.
Preheating temp. / time range:	70 °C-150 °C / 0-5 min.
Heating temp. / time range:	[preheating temp.] to 220 °C / 0-5 min.
Soldering temp. / time range:	[heating temp.] to 280 °C / 0-30 s (0-60 s below 260 °C)
Heat retention temp. / time range:	[soldering temp.] to [soldering temp. – 0 to 50 °C)
Effective soldering area:	280×280 mm (11×11 inch)
Size:	418×372×250 mm (16.5×14.6×10 inch)
Weight:	16.7 kg (net)
Case and finish:	steel, high-gloss gray lacquer finish
CE	compliant
RoHS	compliant

Equipment description

Figure 1.

Control button descriptions

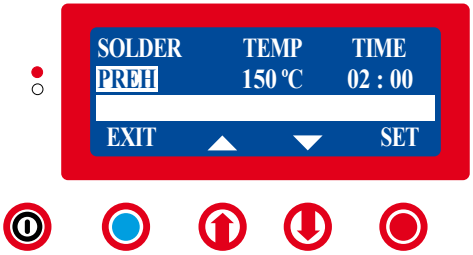


Figure 2.

: press to turn the equipment on or off. It is not possible to switch the oven OFF if it is working or if the temperature has not dropped to a safe level.

or **:** press to change parameter settings.

: press to run set parameters and save settings.

: press to run complete process, exit running process or exit setting process.

Function of the temperature curve

In the SMT production process the temperature curve should be adjusted according to different alloys of solder tin used, as well as the solder paste used, aiming to achieve the best quality of the finished product. Usually, reflow soldering comprises five temperature phases (curve segments). The temperature and the time of each phase can be set to satisfy the combined requirements of different circuit boards. The various temperatures and their role for the reflow phases are described individually.

1. Preheating phase

Heating the PCB from room temperature to 120-150 ℃ serves to evaporate moisture, as well as to eliminate internal stresses and residual gasses of the PCB. By setting a period of 1 to 5 minutes for this segment, preheating is also a gradual transition to the next temperature phase, the optimum time depending on board size and the number of the components.

2. Heating phase

Heating activates the liquid flux contained in tin alloy, enabling it to remove oxide layers from SMDs in preparation for soldering. For low-temperature lead alloy solder and precious metal alloy solder tin, the temperature in this phase should be set between 150 °C and 180 °C, for example, the Sn42%-Bi58% and Sn43%-Pb43%-Bi14% alloys. For mid-temperature lead solder alloys, set the temperature between 180 °C and 220 °C. For high temperature lead-free solder alloys the temperature should be set between 220 °C and 250 °C. If you have reliable technical information on the solder material(s), the temperature of the heating phase can be set to about 10 °C below the tin/solder melting point for best results.

3. Soldering phase

This phase serves to finish the SMT soldering process. It has the highest temperature in the soldering process, hence components are easily damaged if the temperature and/or time are set incorrectly. The process is marked by substantial physical and chemical changes to the solder, which determine to a large extent the success of the entire soldering process. If you have reliable technical information on the solder material(s) in solid and liquid state, the soldering temperature can be set 30-50 °C above the melting point.

Solder material may be divided into three groups:
- low temperature (150-180 °C);

- mid-temperature (190-220 °C);
- high-temperature (230-260 °C).

Currently, lead-free solder materials for high-temperature soldering are the widest used. Low-temperature lead-free variants based on precious metals are also available for special requirements. At present, many lead-free solder materials are no substitute for lead solder as mid-temperature leaded solder has excellent properties in terms of electrical conductance, mechanical behaviour, hot and cold impact resistance, and the ability to act as an anti-oxidant.

In this segment you can set the time according to several requirements discussed below. After high-temperature melting of the solder, all SMDs effectively float on the surface of the liquid solder. As a result of surface tension exerted by the flux and liquid, components will be pulled to the centre of solder pads, causing parts to be repositioned automatically. The solder flux vapour, solder tin and the metal surface of components together form an alloy layer that, by infiltration, yields structures ideal for soldering.

A large PCB surface area and large component pads on the PCB generally govern a relatively long soldering time (10-30 s). However, this stage should be kept as short as possible to protect the components from damage due to overheating.

4. Heat retention phase

This phase enables high-temperature liquid solder to solidify into firm joints. Solidification quality has a direct impact the crystal structure of the solder and mechanical properties. If the solidification process is too fast, rough crystalline will be formed causing a dull solder joint of reduced mechanical strength. Under high temperature and mechanical impact, such solder joints easily crack, eventually causing mechanical and/or electrical breakup and reduced product durability. At slowly declining temperatures, solder can solidify and crystallise properly. Generally set the temperature 10-20 °C below the solder point. When the temperature has dropped to the set value, natural cooling takes over.

5. Cooling phase

During this section of the temperature curve the temperature is reduced to a value that allows PCBs to be removed from the oven without the risk of scalding your hands. To speed up the cooling, you may also stop the process when the temperature drops below 150 °C.

To avoid burns, use tools (pliers, tweezers) or heat resistant gloves to take out the PCB board.

6. Note

In general, start from low-temperature curves, aiming to satisfy the soldering requirements as much as possible to reduce the actual soldering temperature. Also note that longer heat retention times allow shorter soldering times to be used — this will help to protect low-temperature components, especially some types of connector and plug, from melting or deforming. Components that do not fit the soldering temperature requirement should be handled separately after reflow soldering.

Common alloy solder temperature curve adjustment parameters

Solder Type	Composition	Preheat °C /min	Heating °C /min	Soldering °C /30s	Retain ('Keep') °C	Cool
Lead, low-temperature	Sn43-Pb43-Bi14	100-120	130-150	200-210	170	150
Lead-free, low temperature	Sn42-Bi58	100-120	120-130	180-200	150	150
Lead-free, low temperature	Sn48-In52	100-120	120-130	180-200	150	150
Lead, mid- temperature	Sn63-Pb37	130-150	170-180	230-240	180	150
Lead, mid- temperature	Sn60-Pb40	130-150	170-180	230-240	180	150
Lead, mid- temperature	Sn62-Pb46-Ag2	130-150	170-180	230-240	180	150
Lead-free, mid-temperature	Sn96.5-Ag3.5	130-150	180-190	240-250	240	150
Lead-free, mid-temperature	Sn87-Ag3-Cu3-In7	130-150	180-190	240-250	240	150
Lead-free, mid-temperature	Sn91-Zn9	130-150	180-190	240-250	230	150
Lead-free, mid-temperature	Sn95.4-Ag3. 1-Cn1.5	130-150	180-190	250-260	240	150
Lead-free, mid-temperature	Sn99.3-Cu0.7	130-150	180-190	270-280	260	150
Lead-free, high temperature	Sn94-Ag3-Cu3	130-150	190-220	240-250	240	150
Lead-free, high temperature	Sn97-Cu3	130-150	190-220	270-280	250	150
Lead-free, high temperature	Sn95-Sd5	130-150	190-220	270-280	250	150

Common alloy solder physical constants and characteristics

Solder Alloy									Melting temperature	Mechanical properties			Conductivity
Sn	Pb	Ag	Sb	Bi	In	Au	Cu	Zn	Liquidus (°C)	Push Strength (MPa)	Elongation (%)	Rigidity (HB)	
63	37								183	61	45	16.6	11.0
60	40								183				
10	90								299	41	45	12.7	8.2
5	95								312	30	46	12.0	7.8
62	36	2							179	64	39	16.5	11.3
1	97.5	2.5							309	31	50	9.5	7.2
96.5		3.5							221	45	55	13	13.4
	97.5	2.5							304	30	52	9.0	8.8
95			5						245	40	38	13.3	11.9
43	43			14					163	55	57	14	8.0
42				58					138	77	20-30	19.3	5.0
48					52				117	11	83	5	11.7
	15	5			80				157	17	58	5	13.0
20						80			280	28	-	118	75
	96.5					3.5			221	20	73	40	14.0
87		3			7		3		221	45	60	14	9.0
91								9	199				
95.4		3.1					1.5		217				
99.3							0.7		227				
95			5						240				

Operation

There are two working modes to select on the equipment: **Solder** and **Repair**.
The **Solder** mode is designed to solder components onto pads or tracks on the circuit board, the process comprising the phases displayed as **PREH** (preheating), **HEAT** (heating), **SLDR** (soldering), **KEEP** (heat retention) and **COOL** (wait for the machine to cool down).
The **Repair** mode is designed to remove components from the circuit board. This phase has only one temperature section. Before you enter this mode, make sure the correct parameters are set.

Parameters relevant to oven operation must be set on first time use or when the solder tin composition has been changed.

1. Power on

Apply line power to the equipment by operating the rocker switch on the rear panel. The red light near the left corner top of the display will come on. To enter the standby state, press ⏻ on the panel, as shown in Figure 3-1 or 3-2:

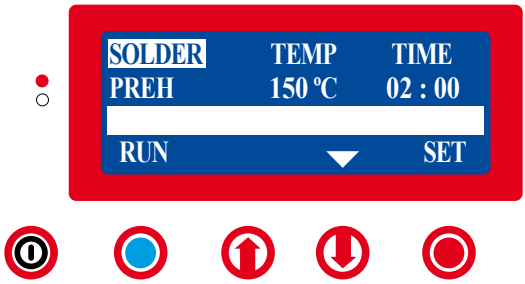


Figure 3-1. Oven standby page in Text-display mode.

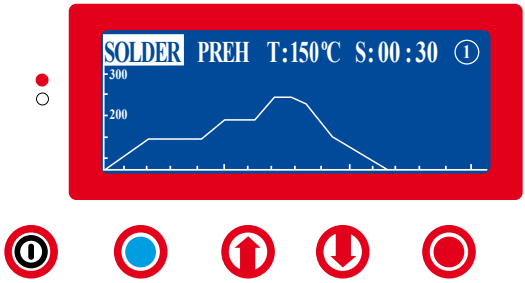


Figure 3-2. Oven standby page in Graphic-display mode.

2. System settings

To enter the system setting mode, turn on the line power switch, then press and hold down the button while pressing the button. As shown in Figure 4-1, the display shows the language and the LCD mode options. Press the or button to select your preference, then press to confirm it and finally press to save the setting.

Figure 4-1. System setting (Text mode).

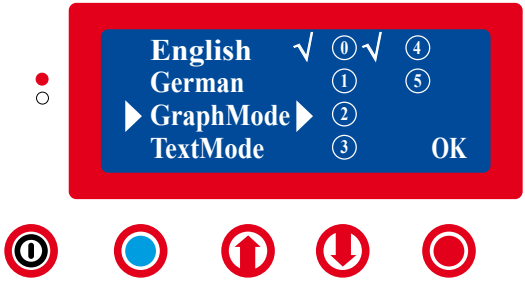


Figure 4-2. System setting (Graphic mode).

As shown in Figure 4-2, one of six curves can be selected. The curve designated '0' is used for user-defined operation, allowing phase temperature and the time to be set. The parameters of the other curves 1 through 5 are fixed. You can find the parameters of each curve in the table in the **Appendix**.

3. Select work mode

Under the standby screen, the display will be show the work state **SOLDER** or **REPAIR.** Press the button to select the work mode.
As shown in Figure 3, press to enter the work state, or press to enter parameters settings. Press the button to exit the operating system.

4. Setting parameters

In the standby menu press ◉ to enter the parameter setting menu. The mode column displays the current mode **SOLDER**. The curve section column displays the currently selected section. Press ⬆ or ⬇ to select the section you want to adjust. Pressing ● takes you back to the standby menu, while ◉ is used to enter the temperature setting state as shown in Figure 5.

Note: *Functionally, the operation using Graphics display mode is the same as with Text display mode. Only the readout is different.*

Preheating (PREH) parameter settings

Press ◉ once to enter the Preheating settings menu, as shown in Figure 5. Press ◉ again to enter the temperature setting menu, as shown in Figure 6. Press ⬆ or ⬇ to change the temperature between 70 ºC and 150 ºC. Press the ◉ button to save, or press ● to discard changes.

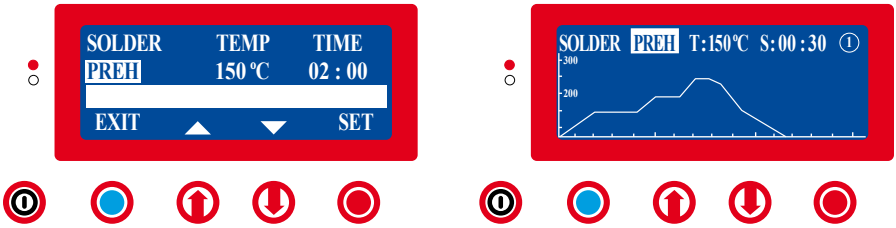


Figure 5. Selecting the PREH(eat) menu (left: Text mode; right: Graphic mode).

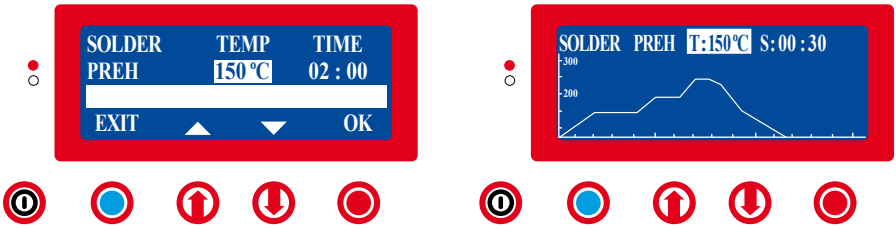


Figure 6. Setting the preheat value (left: Text mode; right: Graphic mode).

After the temperature setting, press once to enter the time parameter setting state, as shown in Figure 7 (8). Press the or key to set the time between 0 and 5 minutes, then press to save the value. Next, press to enter the standby state.

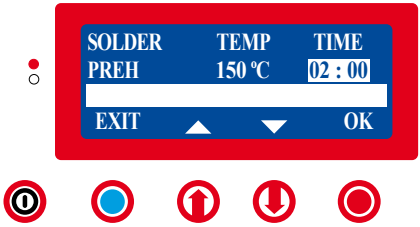


Figure 7.

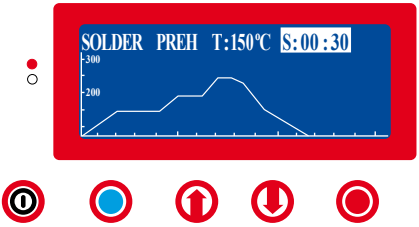


Figure 8.

In Graphic display mode, the curve will be redrawn automatically after returning to the standby state.

Heating (HEAT) parameter setting

As illustrated in Figure 9, press the key to select the heating phase. When the screen displays 'HEAT', press to enter the temperature setting. As shown in Figure 10, you press or to set the temperature to a value between [preheating temperature] and 220 ℃.

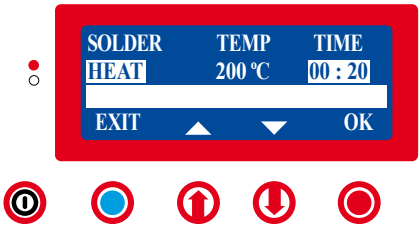


Figure 9.

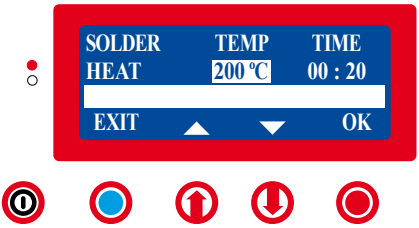


Figure 10.

Press the button to save the temperature setting and proceed to the time setting. As shown in Figure 11, press or to set a time between 0 and 5 minutes. Then press to save the setting and return to Mode Select, or press to enter the standby state, as shown in Figure 12.

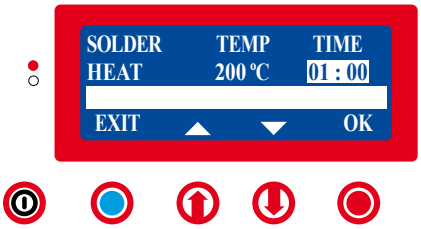


Figure 11.

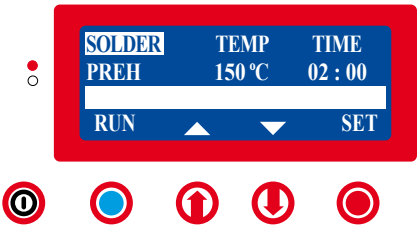


Figure 12.

Solder (SLDR) parameter setting

In the menu shown in Figure 5, press ↓ to select the soldering phase, then press ● to enter the temperature setting menu. Press ↑ or ↓ to adjust the temperature to a value between [heating temperature] and 280 °C. Next, press ● to save the setting and enter the time setting menu.
For temperatures between 250 °C and 280 °C, a time span of 0 to 30 seconds is available. For temperatures lower than 250 °C, a value between 0 and 60 seconds may be set. Next, press ● to save the setting or press ● to discard the modification.

Retention (KEEP) parameter setting

In the menu shown in Figure 5, press ↓ to select the temperature retention phase, then press **SET** to enter the temperature setting menu.
Press ↑ or ↓ to change the setting value and then press ● to save it, or press ● to discard the modification. The software prohibits setting a value smaller than 50 °C below that of the previous phase.

Cooling (COOL) parameter setting

In the menu shown in Figure 5, press ↓ to select the cooling phase, then press ● to enter the temperature setting menu.
Press ↑ or ↓ to change the value from 70 °C to that of the previous phase and then press ● to save it, or press ● to discard the modification.

Repair Mode parameter setting

In the standby menu shown in Figure 13, first press ⬇ to select Repair Mode, then ◉ to enter the temperature setting menu as shown in Figure 14. Press ⬆ or ⬇ to adjust the desired temperature, then press ◉ to save. Repair Mode offers three temperature ranges. For temperatures between 70 °C and 150 °C no time has to be set. For temperatures between 150 °C and 200 °C, the time range is 0 to 60 minutes. For temperatures between 200 °C and 250 °C the time range is 0 to 5 minutes.
After the set time, the oven will shut down automatically.

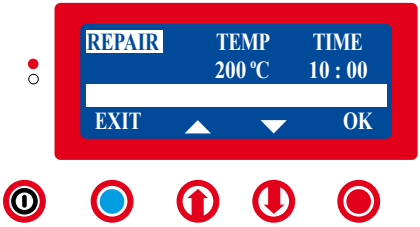


Figure 13.

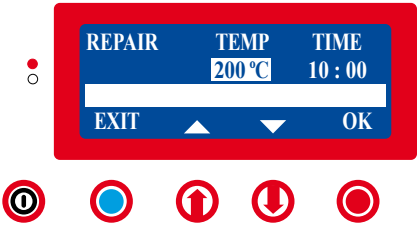


Figure 14.

The soldering process

With all parameters set, the oven is ready to start the 5-phase reflow soldering process. Place the circuit board(s) in the centre of the tray, gently close the drawer and press ◉ to enter the working state, as shown in Figures 15-1 and 15-2. The 'working' indicator on the oven will light up and the screen will display: "Working…" with the temperature and time values being updated as the process evolves.
When the temperature reaches the user-defined value, the time starts to count down. On completion of the count down, the machine will enter the next phase. When the machine finishes working the working lamp will flash or is turned off. Using Graphics display mode, the curve has a broken line as the time goes by, as shown in Figure 15-2. If you want to exit the ongoing process when the machine is running, press the ◉ button.

◉ may also be pressed to stop extractor fan activity (for gas and fume removal) and return to standby mode.

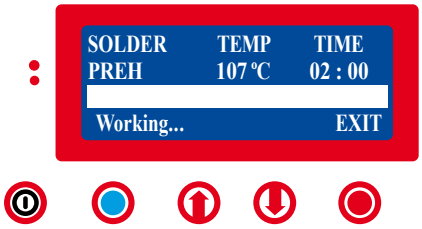


Figure 15-1 (Text mode).

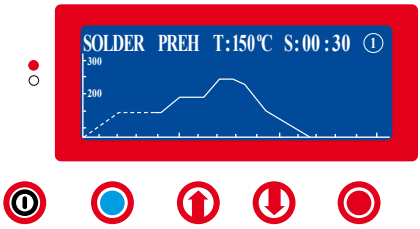


Figure 15-2 (Graphic mode).

During the cooling phase, the fan starts to assist with gas and fume removal. On completion of the cooling phase, the buzzer sounds and the status bar on the display shows "Complete". Press ◉ to repeat the process.

Fault Alarms

1. Dangerous temperature

Highest safe temperatures values apply to each phase while the oven is working. After you switch on the machine it will detect the current temperature. If the temperature exceeds the safe temperature by 10 ºC the display will show **'Dangerous Temperature!'** (Figure 16) and blink. First the buzzer sounds and then the extractor fan starts to work. The alarm stops and the oven returns to normal operation when the temperature drops to the safe level.

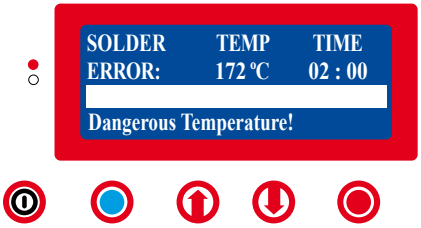


Figure 16.

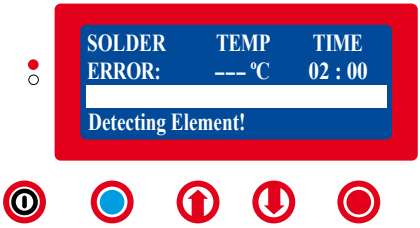


Figure 17.

2. Temperature detection failure

When the temperature-detecting device in the oven develops a fault condition, the screen displays **"Detecting Element!"** as shown in Figure 17. The buzzer is activated and the fan starts to operate. You may press or to quit and return to the standby menu.

3. Heating element failure

When the heating element in the oven develops a fault condition, the alarm will sound and the fan starts to work. The screen displays: '**Heating Element Fault'** as shown in Figure 18. You may press or to quit and return to the standby menu.

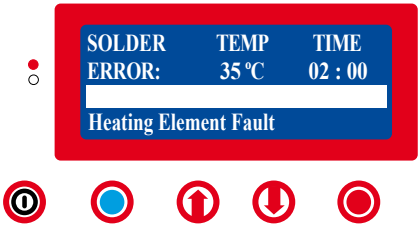


Figure 18.

When an alarm condition arises, the oven will automatically enter the safe mode. If the fan does not come on or the heating element continues to operate, turn off the power immediately and check the fault.

Cautionary Notices

1. Do not connect other equipment on the same power outlet as used for the oven. Make sure the outlet and the power cord maintain a proper protective earth (PE) connection and are rated for at least 10 A (230 VAC version).

2. The Infrared Reflow Oven should be placed horizontally with at least 20 cms (8 inch) clearance to other equipment, objects or walls.

3. Do not use the oven in wet or high temperature environments.

4. Do not use water to clean the oven case.

5. Do not insert anything in the metal grille on the fan, or block the air intake or outlet.

6. Do not place or use combustible or explosive materials in or near the machine. Do not use the oven to dry materials or devices containing combustible gas(es).

7. To avoid damaging the internal infrared heat pipe, prevent objects from impacting the oven case. If a heat pipe malfunction is detected, turn off the power supply and request authorisation to return the unit for servicing.

8. Do not insert your hand(s) in the cabinet when the machine does not indicate that the inside has reached a safe temperature. In case of doubt, wear safety goggles and gloves.

9. To prevent blocking the air intake, do not use the machine when stood on a tablecloth.

10. If the infrared heat pipe is damaged, the replacement part must be authorised by the manufacturer to prevent damage and serious malfunctioning.

Appendix A

Parameters of factory-defined programmes								
Prog.	**PREH**		**HEAT**		**SLDR**		**KEEP**	**COOL**
	temp. (°C)	**time (s)**	**temp. (°C)**	**time (s)**	**temp. (°C)**	**time (s)**	**temp. (°C)**	**temp. (°C)**
1	120	60	160	58	190	30	170	150
2	130	60	180	58	200	30	185	150
3	140	60	200	58	220	30	210	150
4	150	60	220	58	250	30	240	150
5	150	60	220	58	280	30	265	150

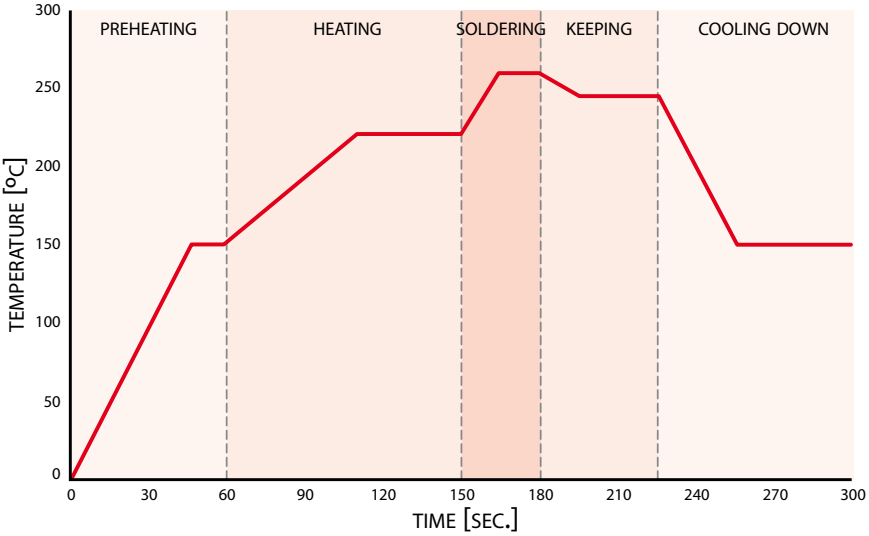
Note: **Prog.** = programme - **PREH** = preheating - **HEAT** = heating - **SLDR** = soldering - **KEEP** = retention - **COOL** = cooling down.
Programme 0 = user-defined.

Appendix B

Functional test at factory

Your oven has been tested at the end of the manufacturer's production line. It is certified to have successfully completed at least two complete reflow processes.
The test was performed using these parameters:

✔ Pre-heating (PREH)	150 ºC for 60 seconds
✔ Heating (HEAT)	220 ºC for 90 seconds
✔ Soldering (SLDR)	260 ºC for 30 seconds
✔ Temp. Retention (KEEP)	245 ºC
✔ Cool down (COOL)	150 ºC



Appendix C

Tray temperature vs. displayed temperature

The temperature value you may read on the display is the oven's internal (air) temperature. This can be slightly different from the temperature measured on the PCB tray. The latter value is marginally lower in most cases.
For this reason it is strongly suggested to run a few dummy tests before starting volume production of boards. The values given in **Appendix A** are good starting points allowing you to tune the various times for best results.

Appendix D

Ball Grid Array (BGA) soldering

Although the equipment is suitable for soldering BGA devices, this should be done with extreme caution, and only if sufficient expertise and experience has been developed by the user(s).
The most difficult aspects of BGA soldering include

1. Component placement — this is extremely difficult by hand and really requires the use of specialized (expensive) optical equipment with camera and even x-ray support;
2. Reflow curve pre-testing — a time-consuming series of experiments may be required to arrive at a 'known-good' temperature curve for successful BGA soldering.

Users should be aware that the soldering BGA devices is a complex task and might fail if he/she has little or no experience. It is recommended to

1. Refrain from using BGAs for any initial or beginners-level experiments with the oven.
2. Attend a hands-on seminar or workshop session on BGA soldering before trying the process on your own.

The substance of the Disclaimer on the second page of this manual is reiterated here.

Warranty statement

Definitions
"The Company" shall refer to Elektor International Media B.V.
"The Package" shall refer to the hardware, software and other component parts of this product.
"The Period" shall be one year from the date of delivery.

Warranty
The Company warrants that this Package is free from significant defects in materials and workmanship for the Period. This warranty is not transferable, and does not include software upgrades.

Checking your product
This Package has been tested in the factory in accordance with the Company's quality guidelines. We strongly recommend that you carry out your own tests with this product, in accordance with the User Test guidelines available for the product, which will confirm for you that this Package meets the specification for which it has been designed.

Exclusions
This Package, or parts of it, should not be used in life-critical applications.
This warranty does not apply in the following cases:
- Where the Package has been damaged as a result of using it in ways other than for which it is intended. Intended use is described strictly in the User Manual supplied with the Package
- Where the Package has been modified.
- As a result of service by a person not authorized by the Company.
- Where damage occurs through improper transportation or packaging.
- Where the Package is damaged through improper physical handling.
- Where parts of this Package are lost or damaged.

The Warranty does not apply to the consumable parts of this Package – e.g. ICs or components supplied with this Package including IC(s) contained in programmable systems which can be damaged by erroneous use.

Disclaimer
Except for the limited warranties made in this document, the Company disclaims all other warranties – expressed, implied or statutory – including, but not limited to, implied warranties of merchantability or fitness for a particular purpose. In no event shall the Company be liable for any incidental, special, or consequential damages, including, but not limited to, loss of business, profits, whether in action, contract or tort or based on a warranty, arising out of or in connection with the use or performance of this Package. The only warranty offered is the repair or replacement of the Package, or parts thereof at the Company's discretion. The Company has the option to offer a refund, at its own discretion, under all circumstances.

Obtaining warranty service
Subject to the provisions above, you are entitled to service with respect to the Package with the following terms and conditions:
Claims will only be honoured if made within the Period.
- Before making a claim, please review the Package documentation – supplied electronically and/or on paper – and contact relevant representatives of The Company.
- If you have problems, please contact the Company by telephone. Your assistance will be required in running any diagnostic tests the Company may feel suitable to ascertain where the problem with the Package lies. This will help in reducing the number of 'no defect found' problems.
- Where a diagnostic test by telephone identifies one component at fault, the Company may send – by post or courier at the Company's expense – a replacement part.
- Where a diagnostic fault determines that an upgrade of software is required then the Company reserves the right to send this using email.
- Where it is not possible to determine the fault and repair it remotely, the Package, or parts of it, will need to be returned to the Company. Please provide proof of purchase and serial numbers for any parts of the Package, as well as proof of shipment.
- The company will seek to determine the fault with all returned Packages.
- Where a returned Package is found to be defective in materials or workmanship, the Company will replace or repair the Package at its own expense.
- Where no fault is found with a returned Package, the Company reserves the right to make a reasonable charge to compensate the Company for the time taken to service the Package.